CHAPTER 11

BEACH AND WEATHER CHARACTERISTICS

INTRODUCTION

The ideal beach for landing craft and amphibian operations is one with deep water close to shore, a firm bottom of hard-packed sand and gravel, minimum variation in tides, and a moderate to gentle (1:15 to 1:60) underwater beach gradient. It also has no underwater obstructions to seaward and no current or surf. Although such a beach will rarely exist in the area of operations, the battalion or unit commander weighs the characteristics of existing beaches against these desirable features (see Appendix C).

BEACH COMPOSITION

Beaches are classified by their predominant surface material, such as silt, mud, sand, gravel, boulders, rock, or coral, or by combinations of sand and boulders. The ideal composition for beaching landing craft and amphibians is a combination of sand and gravel. Silt, mud, or fine sand may clog the cooling system of landing craft. Rock, coral, or boulders may damage the hull or the underwater propulsion and steering mechanism.

Firm sand provides good beach trafficability for personnel and vehicles. A beach is usually firmest when it is damp and when the material is of small size. Gravel has good bearing capacity but poor shear strength. As a general rule, the coarser the material, the poorer the trafficability.

BEACH GRADIENT

Beach gradient or underwater slope is usually expressed as a ratio of depth to horizontal distance. For example, a gradient of 1:50 indicates an increase in depth of 1 foot (.3048 meter) for every 50 feet (15.2 meters) of horizontal distance. For landing operations, it is usually necessary to find the gradient only from the water's edge seaward to a depth of 3 fathoms (5.5 meters). Beach gradients are usually described as–

- Steep (more than 1:15).
- Moderate (1:15 to 1:30).
- Gentle (1:30 to 1:60).
- Mild (1:60 to 1:120).
- Flat (less than 1:120).

Underwater gradients can seldom be determined from hydrographic charts. Only a few areas have charts scaled larger than 1:100,000. Moreover, since the inshore seabed is subject to frequent change, only a very recent survey would have any value. However, there are ways to estimate gradient.

Steep beaches have gradients of more than 1:15. These beaches normally have plunging breakers; but if the gradient is very steep, breakers of an unusual type may exist. In this case, water flowing down the beach fills the curling wave form with water and the breaker rolls over without impact, instead of plunging. This type of breaking leads to swash flow up the beach with unusual velocity and height. Steep beaches tend to become steeper during a period of calm seas. A summer berm advances outward and underwater berms and bars tend to disappear. Generally, steep beaches are composed of coarse sand particles, pea gravel, or gravel. When waves break at an angle on steep beaches, currents are high. They exist throughout the surf zone and for some distance seaward.

Beaches with slopes of 1:15 to 1:30 are beaches with moderate gradient. Plunging breakers are less common on these beaches. Spilling breakers occur most frequently. The probability of each type of breaker depends on the topography of the beach and the type of waves that exist. If a bar exists, plunging breakers may occur at low tide and become spilling at high tide. High, long period swells usually plunge at both high and low tide. When spilling occurs on a bar, the wave frequently re-forms and plunges onto the beach face.

Beaches with a moderate gradient usually have an offshore bar during all seasons of the year, unless the beach is in partly protected bights and bays. When high waves exist, the bar becomes more pronounced and the beach face becomes flatter. During a period of low waves, the beach face becomes steeper and the bar tends to disappear or become discontinuous. These beaches rarely have more than one bar.

Beaches of moderate slope are mainly composed of moderately fine sand. They may have a gravel berm at extreme high water. Where a bar exists, currents are always present in the channel shoreward of the bar. With waves parallel to the beach, these currents are low velocity. When breakers are at an angle to the beach, they may reach a velocity of 4 knots. This flow normally follows the channel for some distance, then flows out over the bar at low points 400 to 5,000 feet apart. These partial channels are called rips, and currents flowing to sea maybe very strong. Where the beach face is steep, strong currents also exist in the inner surf zone.

Beaches with slopes of 1:30 to 1:300 have gentle, mild, or flat gradients. Plunging breakers are less common on these beaches; spilling breakers are the rule. Plunging breakers are usually the result of a temporarily steep section of the profile. These beaches often have several bars. Where long period swells and short period waves exist, a certain amount of spilling takes place on the outer bar. Spilling may obliterate the wind waves, and the swell may re-form behind the bar and plunge on one of the subsequent bars or the beach face. Unless partly protected, beaches of flat gradient usually have several offshore bars. These beaches consist of fine sand. A pea gravel or gravel beach face is sometimes found at the mouths of small creeks. In channels between bars, currents may be very strong.

SEA BOTTOM

Sea bottoms most nearly ideal for landing craft and amphibian operations have coarse sand, shell, and gravel bottoms and similar foreshore beach composition. These bottoms are firm and usually smooth; but bank, bar, and shoal formations are common. Bottom compositions of soft mud or fine, loose sand can be hazardous to boats, vehicles, and personnel. Soft mud and loose sand could foul the engine cooling systems. Crews on craft equipped with beaching tanks rely on this supply of cooling water during beaching operations to prevent engine fouling. Crews on vessels not equipped with beaching tanks must clean the sea strainers often to ensure the engine gets an adequate supply of cooling water. Landing vehicles, tracked (LVTs) and other tracked vehicles sink into beaches with a soft bottom and lose traction. Wheeled vehicles may dig into sand or mud and become immobilized.

Mud and sand bottoms may be either firm or soft, depending on the percentage of sand. A mud bottom over a rock base may be satisfactory if the mud is not more than 1 or 2 feet (.3 or .6 meters) deep. Coral heads, rocks, and other underwater obstructions in shallow waters near shore can cause bent propellers and shafts, broken skegs, and punctured hulls. Rocks covered with algae are extremely difficult for personnel to walk on and may cause wheeled vehicles to lose traction.

SANDBARS

Sandbars are likely to develop offshore of long, sandy beaches that are exposed to continuous wave action. On aerial photographs of quiet sea and clear water, sandbars appear as a narrow band of light tone against a dark bottom. On photographs of rough water, sandbars are detected by a line of breakers outside the normal surf zone.

A sandbar indicates a sandy bottom offshore and unless there are visible rock outcrops, probably a smooth, sandy bottom inshore of the bar. These characteristics, when accompanied by sand dunes behind the beach, indicate that the beach is mostly sand. Surf is likely on such beaches. The height of the surf can usually be estimated accurately under a given wind or sea swell condition if the approximate depth over the sandbar is known.

Sandbars can be a serious menace to landings. Craft may run hard aground on them while still some distance from the beach loading or discharge point. When this occurs and an appreciable sea is breaking on the bar, the craft may swamp and broach to. If troops debark while the craft is hung on a sandbar, they may be endangered due to depth of water, strong currents, or a soft bottom between the bar and the beach. Rather than be endangered, personnel should remain aboard the craft. Successive seas may lift the craft over the bar. Then the craft can proceed to the beach.

If the sea condition permits and the craft is unlikely to free itself from the bar, personnel should be transferred to wheeled amphibians and salvage begun to retrieve the craft. Tidal variations influence the times when beachings can be attempted.

Even though there are no bars on a beach at the initial landing, the scouring action of the propellers of beached landing craft may create them. After several days, a built-up bar of this type may be large enough to prevent the satisfactory beaching of LSTs and similar vessels. Alternating beaching sites reduces this hazard.

Small sandbars may be formed between runnels within the tidal range on foreshores having a slight slope. The height of these bars is seldom more than 2 feet (.6 meter) from the bottom of the trough to the top of the crest. However, such bars are hazardous to operations because landing craft may ground on the crests and troops and equipment must cross the stream of water to reach the dry shore. If the bottom of the runnel is silt, vehicles and heavy equipment may bog down. It may be necessary to beach the craft at high tide and unload it after the water has receded to a point where matting can be laid across the troughs.

Whenever bars are present, the wave crests peak up as the waves roll over the bar. The water depth over the bar and the wave height determine if breaking takes place on or near the bar. If water depth over the bar is more than twice the significant breaker height, nearly all waves pass over the bar without breaking, but crests peak up distinctly. If the depth is between one and two times the breaker height, waves break near the bar, some on the bar itself, and others on the shoreward side. All waves break on the seaward side when the water depth over the bar is less than the breaker height. Frequently, more than one bar exists with waves breaking and re-forming and breaking again on another bar or on the beach.

Various types of bars are found off shorelines. However, three common types of submerged sandbars exist:

- The first type is found offshore of many large rivers and is often associated with deltas. The multiple bars of this type cover a large area and have a wide range in depth often extending above sea level. Charts of these bars are only accurate at the time they are made since the bars change tremendously in size and position during floods and high surf. Generally floods decrease the depth and increase the area of the bar. High surf has the opposite effect.
- The second type of bar is crescent-shaped and extends convexly out from the mouths of rivers and from the bottleneck entrance of bays. Such bars are often shallow enough to seriously hinder landing craft. While it may be advantageous to use beaches in estuaries and bays where the surf is low, access to these areas may be difficult because of high breakers associated with the crescent bars characteristic of these locations. Although the position of the channel may shift, it is likely to remain in the same general location and is readily spotted from the air. While no direct evidence proves this fact conclusively, this type of bar probably deepens during high surf.
- The third type of bar is the type which parallels most sand beaches. In some areas, they occur only during the season of largest waves. Elsewhere, they persist throughout the year. Longitudinally, these bars may continue for miles. However, they are more likely to develop off some portions of a beach more often than others. Breaks in the bars can be detected from the air. The typical depth of the longshore bar ranges from 3 to 15 feet below mean low water. In some very sandy areas, a series of bars may extend miles out to sea; the furthest ones have a depth too great to interfere with watercraft operations.

High surf greatly modifies bar depth and distance from shore. There is a rough relationship between bar depth and the maximum breaker height during the preceding one or two weeks. If the breakers remain constant in height long enough, the bar attains a depth slightly less than the depth of breaking at low tide. Large waves do not ordinarily last long enough to cause this adjustment.

ROCKS

Rocks on a beach may limit the shore approaches so that only a few craft can land at once. This prevents a large-scale landing and restricts beach operations. However, one or two rocky patches fronting a beach do not present a serious obstacle. There is slight chance that craft will strike rocky patches that have been properly marked with buoys.

In a heavy sea, waves break over rocky patches on the bottom. A light sea with waves breaking on the rocks indicates that the rocks are dangerously close to the surface.

REEFS

Coral reefs are found in shallow salt water in tropical areas. The three general types of reefs are–

- Fringing reefs that are attached to the land. The reef may be only a few feet wide and is seldom more than a mile wide. Inshore boat channels are often present on fringing reefs, but they do not occur when the reef is narrow and exposed to heavy surf action. These boat channels are about 1 to 5 feet (.3 to 1.5 meters) deeper than the rest of the reef surface and may be 10 to 50 yards (9.1 to 45.7 meters) wide. These channels run parallel and close to the shore, open seaward through breaks in the reef, and may continue for a nautical mile (1.852 kilometers) or more. The channels trap sediment brought down from the land or shifted inshore from the seaward side of the reef. This sediment is often quite fine, giving the boat channels a bottom of sand or mud, although clumps of coral may live in them. Generally, they are deep enough for the smaller landing craft and too deep for troops to wade.
- Barrier reefs that lie offshore and are separated from the land by a lagoon. There may be a fringing reef on the land side of the barrier reef. Barrier reefs vary in width from a few hundred feet (meters) to more than a nautical mile (1.852 kilometers) and may have reef islands on them.
- Atoll reefs. These barrier reefs enclose lagoons. They usually have a crescent shape with the convex side toward the sea. They may contain reef islands, or heads, composed of accumulated debris from the reef. These circular, drumlike islands are seldom more than 10 to 15 feet (3.1 to 4.0 meters) higher than the reef flat. They may be up to 100 feet (30.5 meters) in diameter with a low, swampy interior. The water surrounding a coral island is usually smooth, and the island's presence may not be indicated by surf. However, the water changes color near the island from deep blue to light brown. The chief obstacles on the seaward side of an atoll reef are the marginal ridge with its consequent surf and the scattered boulders of the reef, which are difficult to spot. The inshore part of the reef is usually critical in landing operations. Often it is a band from 50 to 100 yards wide (45.7 to 91.4 meters) with boulders that may impede vehicular progress. On the whole, the surface of an atoll reef is more favorable for crossing than the surface of a fringing or barrier reef. On the lagoon side, the beaches are apt to be composed of softer sand than the seaward beaches. A landing on the lagoon side should be undertaken at high tide, and the numerous coral colums that grow in shallow water near the shore must be bypassed.

SEAWEED

Seaweed is usually found in calm waters. It may interfere with the operation of landing craft and wheeled or tracked amphibians. The marine growth may consist of free-floating minute particles that clog sea strainer intakes for engine cooling water, or it maybe a thick, heavy type of weed that fouls propellers and tracks.

CURRENTS

When visibility is poor, water currents of variable direction and low, changing velocity may interfere with or prevent landing at the designated point on a beach. When alongshore currents are anticipated, unmistakable markers or landmarks are needed to identify the beach and the approach lines. Even though landing craft compasses may be properly compensated the current and weather may prevent boat operators from following the intended course. Therefore, all boat operators must be aware of natural and artificial ranges that can be used to mark beach approaches during day and night operations. Directing individual craft by radio from a radar-equipped command and control boat or from the vessel being discharged is a satisfactory method during reduced visibility.

A strong alongshore current may contribute to the broaching-to of craft. A broached-to condition exists when a craft is cast parallel to the current or surf and grounded such that maneuverability is greatly reduced. To prevent this condition, boat operators must be extremely careful when approaching, retracting from, or trying to maintain a position on a beach. Broaching-to is dangerous if a surf is running since the craft can be swamped or driven higher onto the beach. In either case, assistance will probably be needed to recover the boat. Unloading broached-to craft is difficult. Injury to personnel and damage to the craft and its cargo may result from attempts to remove cargo when the craft is not perpendicular to the surf or current. If there are very strong alongshore currents, the beach may become cluttered with broached-to and swamped boats unless broaching lines are used or breakwaters and jetties are constructed.

Offshore and inshore currents are very important to watercraft operations. Offshore currents are found outside the surf zone. Tidal currents predominate around the entrances to bays and sounds, in channels between islands, or between an island and the mainland. Tidal currents change direction every 6 to 12 hours and may reach velocities of several knots in narrow sounds. On the surface, tidal currents may be visible as tide rips or as areas of broken water and white caps. Tidal currents are predictable; they repeat themselves as regularly as the tides to which they relate. Nontidal currents are related to the distribution of density in the ocean and the effects of wind. Currents of this type are constant for long periods and vary in direction and velocity during different seasons.

Breaking waves create shore currents within the surf zone. Longshore currents flow parallel to the shoreline inside the breakers, are commonly found along straight beaches, and are caused by waves breaking at an angle to the beach. Their velocity increases with increased breaker height, increased angle to the beach (waves arriving parallel to the beach have an angle of 0 degrees to the beach), and steep beach slopes. Velocity decreases as wave periods increase. Longshore currents are predictable, but the forecast accuracy depends on the accuracy of the wave forecast on which it is based. Where longshore currents are common, sandbars are usually present.

Rip currents flow out from shore through the breaker line in narrow rips and are found on almost all open coasts. These currents consist of three parts: the feeder current, the neck, and the head. The feeder current flows parallel to the shore inside the breakers. The neck occurs where the feeder currents converge and flow through the breakers in a narrow band or rip. The head occurs where the current widens and slackens outside the breaker line. The neck of a rip current is distinguished by a stretch of unbroken water in the breaker line. The outer line of the current in the head is usually marked by patches of foam and broken water similar to rip tides. The head is usually discolored by silt in suspension. Troughs cut into the sand by rip currents with a velocity of more than 2 knots (3.7 kilometers per hour) may form hazards for landing craft. From the air, a rip current appears as a narrow band of agitated water usually marked by breakers.

Waves piling water against the coast cause rip currents. This water flows alongshore until bottom irregularities deflect it seaward or until it meets another current and flows out through the breakers. Once feeder and rip currents form, they cut troughs in the sand and remain in constant position until wave conditions change. Rip currents are commonly found at the heads of indentations in the coast. When waves break at an angle on an irregular coast, the rips may be found opposite small headlands that deflect the currents seaward. Anytime waves break at an angle to the beach, currents form in the surf zone. If the beach is straight, currents flow along the beach as longshore currents. If the beach is irregular, currents flow along the shore for a short distance and then flow out to sea as rips.

SURF

Ocean waves arise as a result of local and offshore winds on the ocean surface. Two types of surface waves are produced: wind waves and swells.

Wind waves are usually steep with a short time between successive crests. Frequently, the crests break in deep water. When crests are small, they are called whitecaps. When crests are large, they are called combers or breaking seas. In deep water, these waves seriously affect the performance of small craft.

Swells result from storms great distances from the coast. They are characterized by a long, smooth undulation of the sea surface. These waves never break in deep water, and time between successive crests may be very long. Small craft in deep water are not affected by swell; however, swell does cause larger vessels to roll and pitch in deep water.

In shallow water, swells increase in height. Upon reaching a sufficiently shallow depth, swells may give rise to an immense surf that may damage shore installations or make harbor entrances impassable.

Wind waves and swell usually coexist in open water. Wind waves may completely obscure swell until near the shore where the swell peaks to a greater height. This may be the first time the small craft operator becomes aware of the swell. Swell arising from distant storms approaches the coast at high speeds. In the case of a large offshore disturbance, the swell usually arrives at the shoreline ahead of the storm. For this reason, vessels trying to reach harbors ahead of a storm may find the entrance impassable due to breaking swell.

The most important difference between breakers of similar height is whether the breakers are the plunging, spilling, or intermediate surging type. Because of the force of energy exerted in a plunging breaker, its impact on watercraft is greater than that of a spilling breaker.

In a plunging breaker, the energy of the wave is released in a sudden downwardly directed mass of water. The wave peaks up until it is an advancing vertical wall of water. The crest then curls over and drops violently into the preceding trough where the water surface is essentially horizontal. During this process, much air is trapped in the waves. This air escapes explosively behind the waves throwing water high above the surface. The loud explosive sound of the plunging breaker easily identifies it during darkness or fog.

In a spilling breaker, energy is not released at once, and the breaking process occurs over a large distance as the breaker travels toward the beach. The wave peaks up until it is very steep, but not vertical. Only the topmost portion of the crest curls over and descends on the forward slope of the advancing wave where it slides down into the trough. This process starts at scattered points that converge until the wave becomes an advancing line of foam.

A surging breaker is seen less often than a plunging or spilling breaker. In a surging breaker, the wave crest advances faster than the base of the wave looking like a plunging breaker. The base of the wave then advances faster than the crest. The plunging is arrested and the breaker surges up the beach face.

NOTE: The relationship between beach slope and the ratio of deepwater wave height to deepwater wave period is shown in Figure 11-1. This figure is an ideal presentation and does not consider such influences as offshore bars and wind chop.

Plunging breakers usually occur on steep beaches rather than flat ones. The disturbing conditions, irregular profile, and bottom irregularities of a flat beach make it more suitable to spilling breakers. However, when plunging breakers do occur on flat beaches, the beach is unusually regular, or has a temporarily steep section of beach in the breaker zone. Beaches in protected bays and estuaries subject only to waves that have undergone considerable refraction or diffraction almost always produce plunging breakers. Under these conditions, the beach profile is normally very regular, disturbing influences are minimal, and short period wind waves have been screened out.

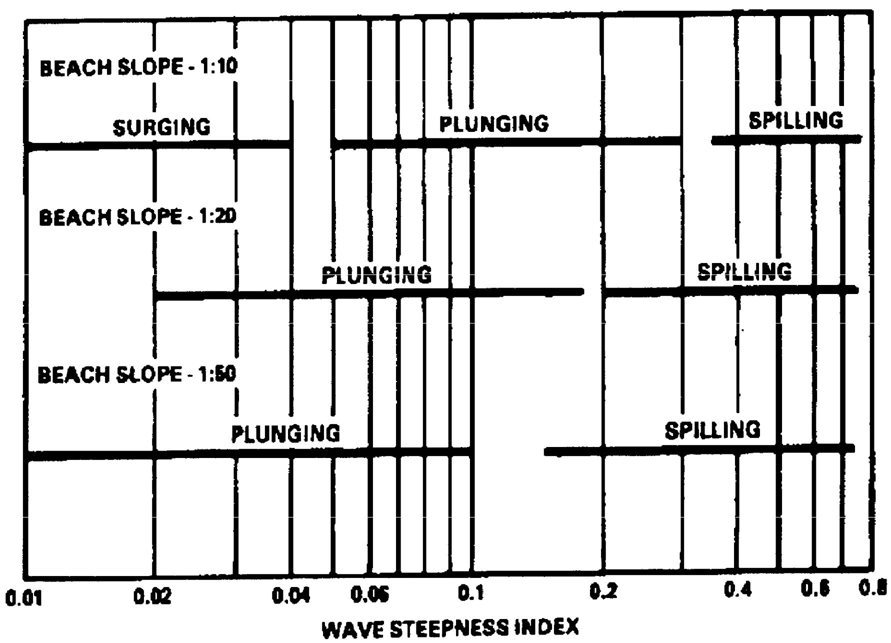
The angle at which waves break in respect to shoreline contours generates a number of complications to landcraft operations. Short-period waves, wind waves, and chop do not undergo any great change of direction when approaching a beach. If their deepwater angle of approach is not normal to the beach, they will break at an angle. Long-period waves reaching a beach with steep offshore slopes may not undergo sufficient refraction to eliminate the effects of direction on the breaker angle. These conditions cause the wave to first strike the beach at one end or the other. The breaking process continues down the beach in the direction the waves were traveling. This action sets up a current in the surf zone traveling parallel to the shore and in the same direction as the wave. For high waves of great angle, this current maybe as great as 3 or 4 knots and imposes difficulty on landing craft traversing the surf zone. These currents have a much greater velocity in certain parts of the surf zone. To successfully traverse the surf zone, landing craft must first estimate the direction and total distance of drift and then direct a course so that the craft meets the breaker's crest head on or directly astern.

The breaker or wave period affects the speed at which the craft encounters breaking waves. Short period storm waves from local sources may occur every 6 to 12 seconds. At this frequency, a craft does not have the opportunity to pass the breaking wave. Such continuous impact may cause an operator to lose his bearing and become disoriented. Long period waves may occur every 10 to 20 seconds. On steepbeaches, landing craft can pass through the breaker zone between waves.

Generally, breakers occurring farthest from shore are the highest. This results from an offshore bottom configuration equivalent in effect to a submarine ridge. This configuration leads waves to converge immediately toward shore. Conversely, areas in the surf zone where outer breakers persistently break closer to shore than elsewhere generally have lower breakers caused by divergence over a small channel. Rip currents in small channels complicate the refraction pattern in these areas. Normally, two opposing situations are present: currents that make the waves converge and the partial channel that makes the waves diverge. If the first condition prevails, the waves may completely converge and break in the middle of the channel. These waves almost invariably are spilling breakers.

As a deepwater wave approaches a beach, it begins to peak up as it feels bottom and continues to increase in height until it breaks. Breakers are normally larger than they appear from the beach. Figure 11-2 shows a method to visually estimate breaker height.

NOTE: The observer on the beach adjusts his position vertically so his line of sight corresponds with an imaginary line from the top of the breaker to the horizon. The vertical distance from this line to the lower limit of the backwash is the approximate height of the breaker. The lower limit of the backwash is the lower limit of the trough between breakers close to the beach. This system is less accurate as the distance between the observer and the wave increases.



Deepwater wave steepness $\frac{H_0}{T^2} = \frac{\text{Wave height in deepwater}}{\text{Wave period in deepwater (squared)}}$

Example:

If the deepwater wave height is 4.0 feet, deepwater period 10 seconds, and the beach slope 1:20; dividing the period squared into the height will give a Deepwater Wave Steepness Index of .04. Entering the graph with .04 and the beach slope of 1:20, the breakers will be of the plunging type.

Figure 11-1. Graph Showing Relationship of Deepwater Wave Steepness to Beach Slope in the Formation of Different Wave Breaker Types.

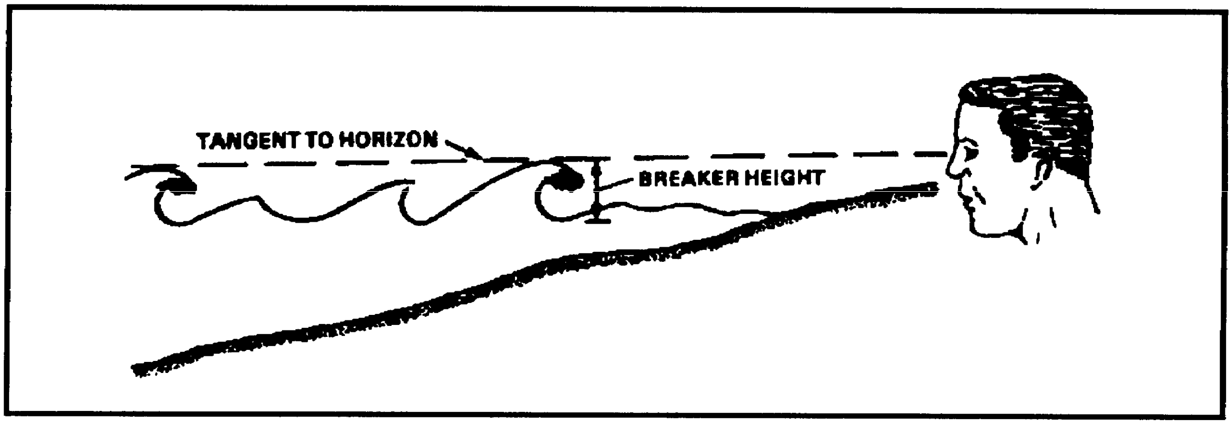


Figure 11-2. Estimating the Height of Breakers.

Surf characteristics can vary considerably with respect to time and location. The degree of variability is difficult to determine. A sequence of waves often seems to have regular characteristics, but surf characteristics are as irregular as the ocean bottom topography over which the swell travels en route to the beach. Any wave system can develop an exceptionally high wave. Its exact time and location can never be predicted. Because of breaker variations, surf observers should record at least 100 breakers to obtain representative values. Under combat conditions, a sample of 50 breaker heights is acceptable.

The speed of a breaker depends on the depth of breaking. For a 6-foot breaker, the depth of breaking is 8 feet, and the breaker advances with a speed of about 10 knots. The relationship of breaker height to breaker speed of advance is shown in Table 11-1.

The surf zone may be divided into two categories: that caused by local winds and that caused by swell from a distant wind area or fetch. A combination of these categories may cause the surf zone to assume a mixed and irregular character.

Local wind waves cause a surf zone with short, irregular crests, spilling breakers, and a generally confused aspect. The steep offshore waves have many white caps. The crests do not increase in height before they break. The wave period is usually every 5 or 6 seconds. Surf zones of this category are found along the continental coasts outside the tropics and in confined waters.

Swell from a distant wind area causes surf zones with regular crests, plunging breakers, and long lines of foam. Breaker or wave period ranges from 8 to 15 seconds, and the crest length at breaking is usually greater than 150 feet. Offshore waves appear low and rounded. Immediately before breaking they peak up sharply, sometimes doubling their deepwater height.

The importance of beach slope to surf is in its effect on the width of the surf zone. The breaker line that represents the seaward border of the surf zone is found where the depth to the bottom is about 1.3 times the significant breaker height. With 6-foot breakers, the breaker line is located where the depth to the bottom is about 8 feet, regardless of slope. On a beach with a slope of 1:10, the breaker line for 6-foot breakers would be about 80 feet from the shoreline; with a slope of 1:50, about 400 feet (Figure 11-3).

Off a very steep beach, there are no lines of foam inside the breaker line. After breaking, each wave rushes violently up the shore face and hits any beached craft with great force. On a flat beach, there are numerous lines of advancing foam. The energy of the waves is expended during the advance through the surf zone, and there is only a gentle uprush and backrush on the beach.

When a wave approaches a straight coast at an angle, the part of the wave first reaching shallow water slows down, while the part still in deep water speeds on. The slowing wave crest then swings around and parallels the coastline. This bending of the crests is called refraction. Refraction also occurs when waves travel over an irregular bottom.

Table 11-1. Relationship of Breaker Height and Advance.

BREAKER HEIGHT (in feet)	SPEED OF BREAKER ADVANCE (in knots)
4	8.5
6	9.8
8	11.0
10	12.2
12	13.3

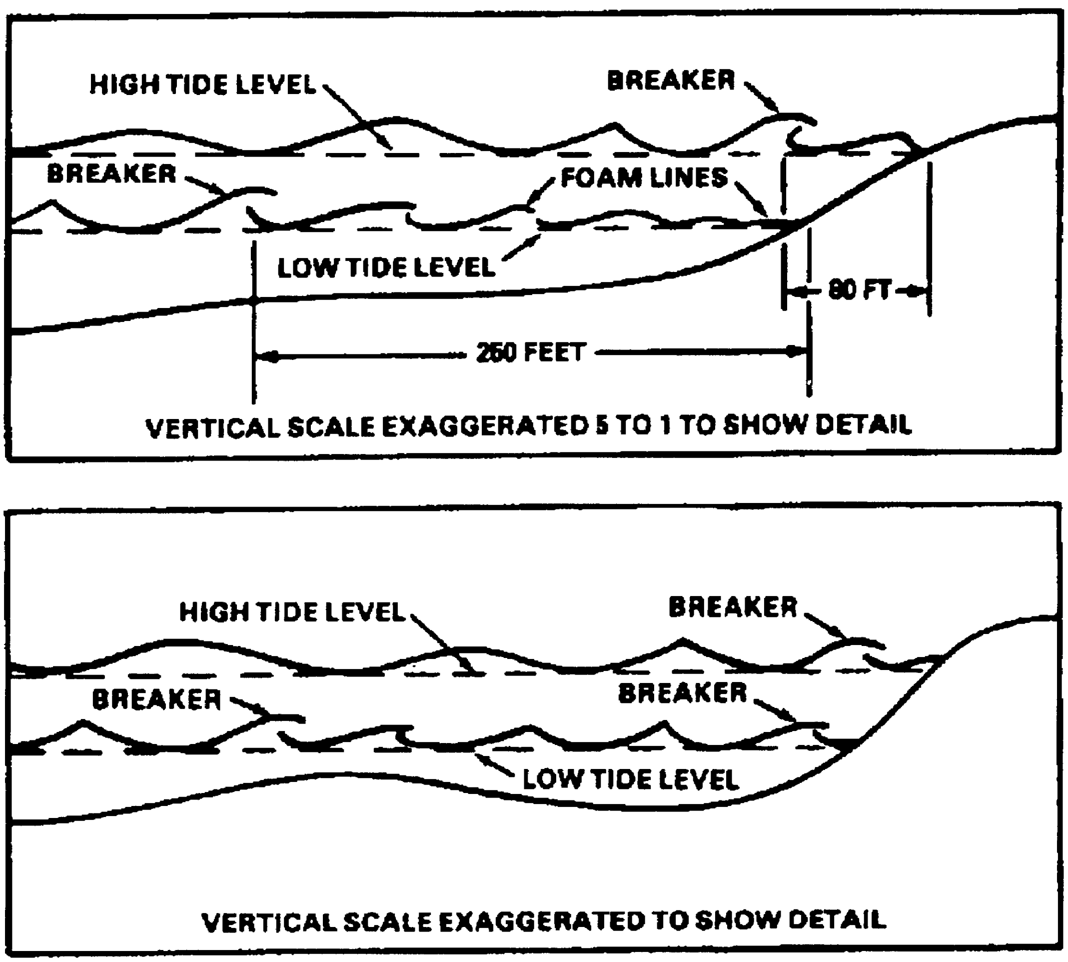


Figure 11-3. Effect of Tide on Surf Zone.

The portion of a wave over a submarine ridge slows down, while the portion on either side swings in toward the ridge. When the waves swing together, each crest is squeezed and the wave height increases. Heavy surf is found wherever a submarine ridge runs out from a coast.

A submarine canyon has the opposite effect. The portion of the wave over the canyon travels faster than the portions on either side and fans out. When the wave fans out, the crest is stretched and wave height decreases. Refraction also causes waves to swing in behind islands and peninsulas where they would not normally reach if they continued in their original direction. The amount of protection afforded by headlands, peninsulas, islands, and other obstructions depends as much on underwater topography as on the coastline's shape.

TIDE

Tide is the periodic rise and fall of water caused mainly by the gravitational effect of the moon and the sun on the rotating earth. In addition to the rise and fall in a vertical plane, there is horizontal movement called tidal current. When the tidal current flows shoreward, it is called flood current; when it flows seaward, it is ebb current.

High tide, or high water, is the rising tide's maximum height. Low tide, or low water, is the falling tide's minimum height. The difference between the level of water at high and low tides is the range of tide.

The period of tide is the time interval from one low tide to the following low tide or from one high tide to the next high tide. These intervals average 12 hours and 25 minutes at most places. About every 2 weeks, during the new moon and the full moon, the highest high water and the lowest low water occur. The combined attractive influences of the sun and moon on the water at these times cause this unusually large range of tide. These tides are spring tides. When the moon is in its first and third quarters, the attractive influences of the sun and the moon oppose each other and the range of tide is unusual1y small. Tides during these times are neap tides. Tides occurring when the moon is at its maximum semimonthly decline are called tropic tides. During tropic tides, the daily range increases. Tidal range also varies with coastal configuration and barometric pressure.

The stage of the tide affects the width of the beach and, accordingly, the type of surf, the depth of water over sandbars and reefs, the width of exposed beach that must be traversed, and the requirements for special equipment to facilitate debarkation. Extreme tidal ranges may restrict unloading to the period of high tide. This requires maximum speed of operation and a rapid, heavy buildup of supplies in the early stages of a landing.

If there is a relatively large tidal range on a gently sloping beach, water may rise or descend on the beach so rapidly that craft are stranded on a dry bottom before they can retract. This may put a critical number of craft out of action until the next rise of tide. If, in addition to a flat gradient, the bottom has many irregularities, a fall in the tide may ground craft far from the beach proper. Personnel will have to debark and wade ashore through these pools. If the pools are deep, a considerable loss of equipment can be expected.

In some cases the effect of the tide may require that craft be held at the beach as the tide recedes, discharging their cargo while resting high and dry on the exposed beach. The craft then retracts on the following tide.

The force of an unusually strong wind exerted on the tide at the landing area may greatly alter the width of beach available for operations. Along with an ebbing tide, a strong offshore wind may blow all the water off the beach and, on a gentle gradient, the water level may recede to an extreme distance from the beach proper. Personnel and material must then pass over a wide exposed beach. On the other hand, a powerful onshore wind can increase the advance of high tide to such an extent that beach installations and activities are endangered or flooded.

Where obstacles do not exist, a landing on a flood tide is generally preferred so that craft may be beached and retracted readily. Normally, it is desirable to set the time for landing 2 or 3 hours before high tide.

WIND

Wind velocity, the distance spanned by the wind, the duration of the wind, and decay distance influence swell and surf functions on the beach.

Winds at or near the surface of the earth have been classified, and their characteristics are known and predictable. Some surface winds are very deep and extend for miles into the air. Some are shallow, such as the land breeze, and extend only a few hundred feet (meters) above the surface. Winds aloft may blow in a direction opposite to surface winds. Velocity and direction may vary with different elevations.

The velocity and duration of the wind and the size of the water area over which the wind has acted to produce waves govern the growth of waves. Swells are waves that have progressed beyond the area of influence of the generating winds.

A very rough sea disrupts landing schedules and formations by restricting the speed and maneuverability of craft. Normal control and coordination problems become more complex. Planners must consider the effects of heavy seas on landing craft when establishing timetables, distances to be traveled on the water, and loads to be carried. With an excessive or poorly distributed load, boats may list severely or even sink. Extremely rough conditions may necessitate removing loads from the craft and placing the craft aboard another vessel or in a safe haven.

When a rough sea is anticipated, craft carry smaller loads and proceed cautiously. Ship-to-shore distances are reduced as much as feasible. Since the unloading of equipment and supplies may be restricted by heavy seas, priorities must be established for critical items so that the most essential shore requirements are met as quickly as possible.

WEATHER INFORMATION

Weather information about the area of operations must be analyzed carefully to determine the probable effect of weather on craft operations and working conditions. Early in the planning stage, the battalion commander must find out what source will furnish weather information and in what manner.

The success of a tactical operation may depend on a sequence of several favorable days after the initial landing has been made. The most important consideration is the sea and swell caused by high winds and storms. Excessive sea and swell may end the movement of later serials, thus placing the assault troops in a precarious position ashore. P1anners must consider beaching conditions, unloading conditions, speed of vessels, the effect of wind and sea on the tides, and the physical condition of the troops.

Alternate plans for a waterborne movement must consider possible variations from average weather. Weather conditions en route to the area must also be considered. In a tactical operation, maximum advantage must be taken of weather conditions that might conceal an approach to the objective area.

If the approach is made in calm, clear weather, the enemy can locate the attack force and the landing area more easily, and his air attacks will not be impeded. Bad weather, storms, fog, and winds affect the movement, but they also force the enemy to rely on more indirect and less dependable means of attack and of determining the target area.

Weather information is a communications priority so that plans may be made or altered without delay, especially if unusual weather conditions are anticipated. In estimating the effects of weather on an operation, planners must consider the –

- Direction and speed of winds at the surface and in the upper air, the likelihood of storms, and the nature of storms typical to the target area.
- Distance at which objects can be seen horizontally at the surface and both horizontally and vertically in the upper air.
- Restrictions imposed on visibility by fog, haze, rain, sleet, or snow.
- Effect of extreme temperatures on personnel and materiel.
- Effect of excessive rain or snow on personnel and materiel.

WEATHER FORECASTS

Weather prediction is based on an understanding of weather processes and observations of present conditions. Weather forecasts are based on past changes and present trends. In areas where certain sequences follow with great regularity, the probability of an accurate forecast is very high. In transitional areas (or areas where an inadequate number of reports is available), the forecasts are less reliable. Such forecasts are based on principles of probability, and high reliability should not be expected. A forecast for 6 hours after a synoptic chart (weather map) is drawn should be more reliable than one for 24 hours ahead. Long-term forecasts for 2 weeks or a month in advance are limited to general statements. For example, the area which will have temperatures above or below normal and how precipitation will compare with normal is predicted, but no attempt is made to state that rainfall will occur at a certain time and place.

Synoptic forecasts are used mainly for day-to-day forecasts. They are developed from reports received from a widespread network of stations that make simultaneous observations at prescribed times. Data from these observations are transmitted to a weather center and analyzed. The resulting forecast is forwarded to the operating units concerned. This type of forecast requires a dependable system of communications. The observers must be located over a wide area, possibly including enemy territory. Synoptic forecasts suitable for landing operations can be made only 1 to 2 days before the operation, but such forecasts will generally be dependable.

Conditions beyond the range of synoptic forecasts are estimated by the statistical method. This method relies on weather observations accumulated over a period of years and describes the average weather that may be expected in a given area. It shows such information as the strength and direction of prevailing winds, average temperatures, and average precipitation. If weather records at a given area have been kept for a number of years, the statistical study will be correct about 65 percent of the time.

The value of a forecast increases if the information on which it is based is available and the principles and processes involved are understood. The factors that determine weather are numerous and varied. Increasing knowledge about them continually improves weather service. However, the ability to forecast is acquired through study and long practice. The services of a trained meteorologist should be used whenever possible. Data about average weather conditions are essential in planning a landing operation, but assault landings require current information. A forecast that is 24 to 36 hours old is not reliable.